imposes a periodic, binary phase-flip profile between 0 and π that alternates across the seven lobes of the HOM ribbon-fiber eigenmode, as expected from guided-mode symmetry considerations. For this simulation, the modal conversion efficiency is theoretically nearly 97% and is limited primarily by numerical errors.

Experimental Results

FIG. **6** shows an experimental layout of a mode-converter, which uses a pair of computer-controlled, phase-only spatial, light modulators, SLMs, to emulate a pair of diffractive optic elements (DOEs), as required for the system (recall, FIGS. **4**; **410** and **420**). The key components of the test-bed include the pair of SLMs, SLM-1 (**610**) and SLM-2 (**620**), and a transform lens **630**, of focal length f_1, situated at the mid-plane between the SLMs (spaced apart by $2f_1$ along the optic axis). The experimental apparatus also includes a diagnostic module **680** that provides video monitoring of the near-field and far-field system outputs, along with auxiliary optical components, including a laser, optical isolator and beam-forming optics. (The auxiliary components are not fundamental to the results and, hence, will not be discussed further.)

For this demonstration, the phase profiles imposed upon the respective SLMs were similar to those determined in the previously described simulation, as shown in FIG. **5**C (**530**) and FIG. **5**D (**540**), respectively. The test-laser's output is collimated and magnified to a size that is appropriate for incidence upon SLM-1. The diffracted output is picked-off by using a right angle-prism and imaged onto SLM-2. The diffracted output of SLM-2 is again picked-off with another prism.

The resulting far-field and near-field intensities are measured using standard CCD cameras, with the video data shown in FIGS. **7**A through **7**E). FIGS. **7**A and **7**B show the recorded camera images at the two Fourier planes, or, equivalently, the far-field and the near-field of SLM-2, respectively. FIGS. **7**C and **7**D show a line scan profile, taken across the respective far-field and near-field images.

FIG. **8**A and FIG. **8**B show the respective calculated far-field and near-field amplitudes and phase profiles, referenced to the plane containing SLM-2. These results are all derived from the measured far-field and near-field intensities recall the data shown in FIGS. **7**A through **7**D). Shown in FIG. **8**A is the far-field amplitude **810**, as calculated using the measured far-field intensity; and, the far-field phase profile **820**, as retrieved by the G-S algorithm. The similarly derived near-field amplitude **830** and near-field phase profile **840** are shown in FIG. **8**B.

As expected, the near-field amplitude profile (**830**) in FIG. **8**B is comprised of a 7-lobed structure, which is to be compared against the constraint used in the simulation (**520**), as shown in FIG. **5**B. The overlap integral of the experimentally derived field (**830**) with that used in the simulation (**520**) for the ribbon fiber's 7th eigenmode is 84%, which is to be compared against a predicted value of 97%. In terms of the experimental apparatus, the conversion efficiency is limited, to a certain extent, by the uncertainty in determining the precise location of the Fourier-planes along the optical axis, the optical quality of the Fourier transform lens, as well as by the finite spatial bandwidth of the SLMs, the latter of which, in the face of large phase jumps across pixels, results in systematic high-frequency spatial ripples in the near-field, with a concomitant reduction in conversion efficiency. In terms of the phase retrieval computation, the goodness of the derived phase profiles can be systematically affected by the convergence properties of the G-S algorithm. Nevertheless, the measured correlation of 84% compares favorably against the value of 97%, as predicted by our model.

MOPA System Embodiments

Turning now to FIG. **9**, a Master Oscillator Power Amplifier (MOPA) system, capable of providing a TEM_{00} output mode, is shown. This system utilizes two mode converters. One mode-converter, **930** positioned in the low-power leg of the system, is used to enable efficient coupling of a fiber seed laser **910**, assumed to operate in a single mode (LP_{01}) into a desired HOM of a ribbon fiber power amplifier **920**. A second mode converter **940**, positioned in the high-power leg of the system, is used to enable efficient mode conversion from the HOM output of the ribbon fiber amplifier into a desired final output beam, which, as an example, can be designed to be a TEM_{00} mode. The mode converters **930** and **940** are similar in design relative to that described previously (**400**) with respect to FIG. **4**, with the second module (**940**) essentially functioning in reverse, by reciprocity, with respect to the first module (**930**).

Turning now to FIG. **10**, an embodiment similar to the single-pass MOPA configuration described in FIG. **9**, is shown. In this case, the system is augmented with a means by which to actively compensate for fixed and/or dynamically varying optical distortions within the components. Examples of static aberrations include deviations from ideal HOM operation and/or modal preservation of the desired mode in the ribbon fiber amplifier (due to imperfections, dimensional variations, scattering, etc.). Dynamic distortions can include mechanical and thermal perturbations of the fibers, life-cycle degradation of the active media, etc. Since the mode converters are designed assuming a well-defined, stationary HOM spatial profile in the ribbon fiber, deviations from such will result in a loss of efficiency, since the converter is essentially a fixed matched filter.

Returning to FIG. **10**, the compensated MOPA system is comprised of a pair of mode converters **1030** and **1040**, a seed laser **1010**, and a HOM ribbon fiber power amplifier **1020**. Real-time adaptive optical compensation is achieved by sampling a fraction of the output spatial profile, via beam splitter **1060** and detector/wavefront error sensor **1070**, reconstruction of the phasefront, via processor **1080**, and a phase-only SLM **1050**. Since the SLM is in the low-power leg of the system, optical power-handling issues are circumvented, enabling the use of a variety of low-power handling devices. Using conventional servo-loop control techniques and/or genetic algorithm processing, a feedback error-correcting (spatially encoded) signal is imposed onto the SLM to drive the wavefront errors to zero (ideally). In this manner, the amplified output beam can approach that of a diffraction-limited TEM_{00} mode.

Turning now to FIG. **11**, an alternate compensated MOPA embodiment is depicted, referred to in the art as a phase-conjugate MOPA system. This architecture can provide real-time compensation for system aberrations and coupling inefficiencies (both static and dynamic distortions). Note that this embodiment involves a double-pass configuration, whereby the forward-going, amplified HOM mode is wavefront-reversed by a phase-conjugate mirror, and, in the process, retraces its path, thereby traversing the ribbon fiber amplifier in a reverse sequence. The basic system elements are similar to those depicted in FIG. **10**, including the low-power oscillator **1110**, a mode-conversion module **1130**, and a HOM power amplifier **1120**. Note that, in this case, only a single mode-converter module **1130** is required, as the beam will double-pass all the system components. In this configuration, the amplified, forward-going ribbon fiber output beam is directed to a phase conjugate mirror (PCM) **1140**. PCMs are well-known in the art, and function via a variety of nonlinear optical mechanisms (stimulated scattering interactions, opti-